Building a Historical Perspective of the Nuclear World

Introduction

A little over 50 years ago, work at Los Alamos and elsewhere in the world set in motion developments in military and civil applications of nuclear science and technology. Over the years these ongoing developments have shaped history. The resulting “Nuclear Age” has had a significant impact on many aspects of society -- nationally and internationally.

The Manhattan Project of the “Second World War” represents the most remarkable congregation of scientific minds in human history. New scientific ground was broken which helped to produce numerous additional discoveries. Modern computer theory largely grew from bomb-related research with the first huge mainframe computers being used mainly for bomb design.

Dramatic global political changes, including the end of the Cold War, provided opportunity and incentive for thoughtful examination and application of the nuclear enterprise. The continuation of research at Los Alamos National Laboratory after the war was intended to explore and expand the evolution of “things nuclear”.

But the mixture of innovative technology, institutional factors, and policy decisions that govern the nuclear industry did not begin with the creation of the Manhattan Project. Today's world has a past, sometimes ominous, sometimes frivolous, but always connected to future. As George Orwell once said, “He who controls the past controls the future. Who controls the present controls the past.”

Our attempts to create a historical curriculum are motivated by the practical need to tie long-range objectives back to near-term actions and decisions through achievable steps and milestones. A second principle guiding our efforts is perhaps best expressed by University of California, Santa Cruz, Professor John Schaar: “The future is not a result of choices among alternative paths offered by the present, but a place that is created-created first in mind and will, created next in activity. The future is not some place we are going to, but one we are creating. The paths are not to be found, but made, and the activity of making them changes both the maker and the destination.” What paths were taken that have led to our present situation? What conditions, economic, political, social/cultural, led people down the path that resulted in the development and deployment of the first nuclear weapons?

Exactly where our current situations may lead us, of course, is not known, but it is certain that the future has been shaped both by unanticipated events and intentional actions from the past. Our task, then, is to think broadly about what was desirable and possible without abandoning the realm of possibility for tomorrow. We can not change the past, but we can learn from it.

In this spirit, this Critical Issues Forum Project curriculum does not attempt to lay blame on past endeavors but rather to explore alternative reasons and their implications that led to them. In doing so, we hope to gain a deeper understanding that will guide our own actions as well as provide information relevant for current and future policy dialogues.

We've chosen to address a rather expansive 10,000-year period, a realistic boundary given that technology development and implementation generally took centuries due to political and religious realities.

March 17, 1996 was the 50th anniversary of the Acheson-Lilienthal Report, which began efforts to place all applications of nuclear science and technology under international control. Such international control did not come to pass. During the ensuing 50 years, a fabric related to nuclear affairs, civil and military has been woven from threads of bilateral, multilateral, and international arrangements. The implications for mankind of the potential-for good and ill-of the energy of the nucleus of the atom are still global, indeed more so today than in 1946. The fact that this potential will continue to be a major issue in world affairs is the driver for our developing an understanding of the past.

Task Assignments for Building a Historical Perspective of the Nuclear World

Task #1 – The Early Years

> *"...our eyes once opened,...we can never go back to the old outlook....*
> *But in each revolution of scientific thought new words are set to the old music, and that which has gone before is not destroyed but refocused*
>
> *-A.S. Eddington*

A long time ago, in a far away world, a world of beauty unscathed by machines, a small band of early humans scoured the land in search of food and shelter. The days were dry and hot, the nights cool and clear. Early evening on a particularly clear night, lit up by a full moon, one inquisitive member of the band stood on the edge of a cliff looking at the bright orb that seemed only inches away. Reaching out to grab the bright object, the creature fell to its death. What made it reach out? Did it not know that the moon was a quarter of a million miles away? What might the other members of the band have thought? Would they too try to reach out and grab the moon?

From early civilizations to the present, humans have endeavored to understand their surroundings. These endeavors have led to great discoveries that have changed the course of history and of humankind. Throughout history (and pre-history), people have tried to control nature, to explain it in simple terms, to influence the world around them. This task takes us back to an earlier time to investigate ancient beliefs and to begin to formulate an understanding of the development of modern science, economics, politics, and social/cultural groupings

> *"Mine is the first step and therefore a small one, though worked out with much thought and hard labor. You, my readers or hearers of my lectures, if you think I have done as much as can fairly be expected of an initial start. . . will acknowledge what I have achieved and will pardon what I have left for others to accomplish"*
>
> *- Aristotle*

Your first task is to compare and contrast the endeavors of science and technology during two early time periods. The first period, 8000 BC to 1400 AD and the second period being the Renaissance period up to 1800. Using these as reference points, focus your research in relation to the two time periods

You must examine events that established the foundation corner stones from which science and technology today is based. Scrutinize these events in the context of the time periods. Research and gather data, within the context of the four domains (science, economic, social/cultural, and political/geo-political), that help you build an understanding of the dawn of science and technology.

- Compare the thought driving the understanding of the world in each of the time periods. (What is science, as it would have been defined during these periods? How is it different from other ways of thinking? How does it differ from technology of the time?)
- Describe the “scientists” of the time? (How did they think and what was their approach in explaining their physical world?)
- Describe the development of technology (cite examples) from these time periods. (How did technological advances affect the science of the day? How did scientific advances affect the technology of the day?)
- Describe how the political and social environments of the day (cite examples) impacted the pursuit of science and the development of technology?
- Compare the attitudes toward scientific endeavor in the western civilization with the eastern civilization and describe how these attitudes affected the advancement of science and technology? (Compare the differences in the two civilizations that produced unique approaches. How was each civilization affected as each neared the nineteenth century?)

Suggested Classroom Activities for Task #1

The following activities and questions are "hooks" for the work which is to come. While they are intended to generate discussion and promote understanding of and interest in the task, they are not directed specifically at any task question.

This task focuses on two time periods. The first period, 8000 BC to 1400 AD and the second period being the Renaissance period up to 1800. Using these as reference points, address the following in relation to the two time periods:

1. Have a mock class dialogue between Aristotle and his students. Have your students identify possible members of Aristotle's class. Assign one student the role of Aristotle. Students should prepare themselves to act, as they would have during Aristotle's time. Each student might present "visuals" which capture and categorize their ideas while convincing the other members of their point of view. Be sure to consider the four domains (political, scientific, social/cultural, and economic) in developing.
2. Develop comparative charts or database identifying new technologies of the time. Refer to each of the domains (How did the new technology affect each domain?).
3. You are one of the "members of a campaign management team" for one of the Greek nations. As part of the political process, you are tasked to help the King select a new science advisor. The two main candidates are on opposite sides when describing the physical world. As a campaign management team, you must come up with a position on the following questions: What is the world's perception of the natural geological and meteorological occurrences? Are intelligence and communication skills a determinant of great power status? What power does a science advisor really have? Do we really need to understand the essence of life, where rain comes from, ...? What responsibility do we have to the general population? What are the benefits of understanding our physical world for our nation? The risks?
4. Prepare campaign materials like brochures, bumper stickers, position papers, and TV and newspaper ads defining your ideas on the future of your nation's development of explanations of the physical world. Refer to the four domains.
5. Your firm has been hired as consultants to the government. You must prepare a report on the impact of developing reasoned explanations for the physical world. You must answer the following questions: Why would you want to understand the physical world? What benefits would this have for the citizens of your nation? Would the world be a better place if we understood the physical occurrences? Would this be a realistic goal? What kind of infrastructure is needed to develop and disseminate reasoned explanations to the populace? What will it cost? What sacrifices would need to be made? How will it effect our national status? Can you truly be considered a great civilization today without

reasoned explanations for the physical world? How could our new reasoned capabilities be exploited within the framework of existing treaties and current power structures?
6. As a study group within King Arthur's scientific society, you have been researching the legacy left by the development of bow and arrow, including errors and accidents including their use in "Holy Crusade". Your present task is to develop a strategy for disseminating the results of your research. Design a plan for transferring this information to your outlying regions.

1. Brainstorm, capture and categorize issues you feel would be relevant motivators for a nation to pursue/not-pursue a reasoned explanations of the physical world
2. Brainstorm, capture and categorize questions that need to be explored
3. Develop comparative charts or databases identifying explanations of;

- thunderstorms
- solar eclipses
- earthquakes
- the common cold
- creation of gun powder
- transmutation of a caterpillar to a butterfly
- a fever

4. Develop arguments that could have been used by the "Wizards" for failure to control the weather (work within the constructs of the four domains)
5. Considering that "Wizards" of the "Dark Age" were considered indispensable to the rules of the nation states, determine the significance of the following:

- What is the world's perception of solar eclipse?
- Is the "power of a Wizard" a determinant of great power status?
- What power does a "Wizard" really have?
- What challenges did nations/the world likely face during the "Dark Ages"? (keep in mind the four domains)
- What were the lessons learned during each of the two time periods?
- What are the effects of these lessons on newly developing scientific theory?
- How can these lessons learned be transferred and applied without political repercussion?
- What have we learned from these studies?

The following questions are added to help build a deeper understanding that the "work of great scientists and mathematicians" did not occur in a cultural vacuum, that their work was impacted and had an impact on those that came before and after them.

1. What does the term "Metonic cycle" mean? What significance does it have in the history of science and mathematics?
2. The "Merton College Theorem" had considerable importance in the work of Galileo and Newton. See if you can find out how and why.
3. If trigonometry was "reborn" in about 1464, when was its "first birth"?
4. What is the mathematical process called a "method of infinitesimals" and what special place does this idea have in the history of mathematics and science?
5. The eighteenth century saw some of the earliest works on probability theory, chance, and gaming. What is the connection among these three things?
6. What is "scholasticism" and what is its role in the development of science in the Middle Ages and later?
7. Dante's Divine Comedy is essentially a work of literature. What significance does it have as it pertains to the sciences?
8. In what ways was Descartes' Principia like Newton's Principia? In what ways were the different?
9. In 1698, Thomas Savery received a patent on his steam engine, and yet it was more than a quarter of a century later that James Watt made the steam engine commercially efficient. What caused the delay in its widespread use?
10. What is meant by the term "alchemy"? What can you learn about its development up to the Middle Ages?
11. What do the fates of Priestley and Lavoisier tell us about the relationship of science to the politics of a society?
12. In 1543, Vesalius published De Humain Corporis Fabrica. Why is this book regarded as a turning point in the history of biology?
13. The experiments of Redi, Needham, and Spallanzani in 1668 were all directed toward answering the same question. What was the question and to what conclusions did each of these men come?

Task #2 – The Golden Age of Science

> *"Fortunately science, like that nature to which it belongs, is neither limited by time nor by space. It belongs to the world, and is of no country and no age. The more we know, the more we feel our ignorance; the more we feel how much remains unknown....."*
>
> -Humphry Davy
> November 30, 1825

Sometimes called the Golden Age of Science, an era when science seemed to be at the forefront of human activity, the 19th century was a time of major breakthroughs toward deeper understanding of the physical and life sciences. It was a time when science came into its own and commanded the attention of society. Science of the time gave impetus to technology, new perspectives to social understanding, and stimulated the arts. It was a time when scientists discovered approaches outside of the scientific method.

This task area focuses on the Golden Age of Science, 1800 to 1885. This period marks the dawn of a time when expanding scientific knowledge and technological advances virtually created the positive, can-do spirit of the Victorian era. But all was not rosy; undercurrents resisting change existed throughout the century.

Your task is to compare and contrast the endeavors of science and technology during the early to midyears of the nineteenth century.

You must examine events that began to establish the corner stones from which nuclear science and technology grew. Scrutinize these events in the context of the time periods. Research and gather data, within the context of the four domains (science, economic, social/cultural, and political/geo-political), that help you build an understanding of the "Golden Age" of science and technology.

This task focuses on the Golden Age of Science, 1800 to 1885. This period marks the dawn of a time when expanding scientific knowledge and technological advances virtually created the positive, can-do spirit of the Victorian era. Using this as a reference point, address the following in relation to the time period:

1. Compare and contrast the evolution of science in the nineteenth century to earlier centuries? How does it differ from the evolution of technology during the same time periods?

2. Politically and economically, the sense of the period was not universally positive. How did the political and social environments of the day (cite examples) impact the pursuit of science?

3. What was the impact of the industrial revolution on the advancement of science and technology? Discuss the differing views toward the growth of science and technology during this period of time.

4. Explain why science moved toward specialization into specific disciplines and subdisciplines (i.e., chemistry, physics, astronomy, biology, organic chemistry, and genetics).

5. Sir Issac Newton wrote in an earlier time; "I wish we could derive the rest of the phenomena of nature by the same level of reasoning from mechanical principles, for I am inclined by many reasons to suspect that they may all depend on certain forces." What did Newton mean by this statement and what affect did such thinking have on science during the nineteenth century?

6. The English poet, John Keats wrote that he was "certain of nothing but the holiness of the hearts affections, and the truth of imagination. What the imagination seizes as beauty must be truth..." Explain the affect that such romanticist writing had on the scientific endeavor during the nineteenth century.

7. The idea of an unsplittable particle was first conceived by a 5th century Greek thinker named Leucippus. Trace the evolution of the concept of atoms from Leucippus to John Dalton.

Suggested Classroom Activities for Task #2

The following activities and questions are "hooks" for the work which is to come. While they are intended to generate discussion and promote understanding of and interest in the task, they are not directed specifically at any task question.

This task focuses on the time periods known as the "Golden Age of Science", from 1800 AD to 1885 AD Using this as reference points, address the following in relation to the time period:

1. Have a mock debate between three prominent nineteenth century scientists discussing the importance of the principle of the conservation of energy. Have your students identify possible scientists to role-play. Assign one student the role of moderator. Each student should prepare himself or herself to act as they would have during Victorian time. Each student might present "visuals" which capture and categorize their ideas while convincing the other members of their point of view. Be sure to consider the four domains (political, scientific, social/cultural, and economic) in developing arguments.
2. Develop comparative charts or a database identifying new technologies of the time. Refer to each of the domains (How did the new technology affect each domain?).
3. Your firm has been hired to prepare a report on the impact of new scientific discoveries for the general populace. You must address the following discoveries within the context of the four domains:

- hybridization of wheat
- observations of the digestive system
- identification of the nucleus of a cell
- cell theory (both plant and animal)
- antiseptic procedures
- non-Euclidean geometry
- classification of clouds
- reconstruction of fossils on basis of skeletal fragments
- wave theory of light and heat
- electromagnetic induction
- principles of photography
- speed of light
- organic chemistry

Why is it important for the general population to know about these new scientific discoveries? What benefits would these discoveries have for the citizens of your nation?

What kind of infrastructure is needed to develop and disseminate reasoned explanations for these discoveries to the populace?

4. As a study group within Queen Victoria's scientific society, you have been researching the legacy left by previous scientific discoveries. Your present task is to develop a strategy for disseminating the results of your research. Design a plan for transferring this information to your outlying regions.

The following questions are added to help build a deeper understanding that the "work of great scientists and mathematicians" did not occur in a cultural vacuum, that their work was impacted and had an impact on those that came before and after them.

1. What is projective geometry?

2. When Laplace spoke of a "Devine Calculator", he was simply articulating a widely held view of the state of physics in his lifetime. What was that view? Do we hold it still today?

3. What was the reaction of the medical profession to the suggestions about antiseptic procedures in hospitals during the early nineteenth century?

Task #3 – The End of Hope and Promise

> *"The problem does not appear so hopeless when misleading metaphor is discarded. It is*
> *not our task to probe; we learn what we do learn by awaiting and interpreting the messages dispatched to us by the objects of nature. And the interior of a star is not wholly cut off from such communication. A gravitational field emanates from it... Radiant energy from the hot interior after many deflections and transformations manages to struggle to the surface and begin its journey across space. From these two clues alone a chain of deduction can start which is perhaps the most trustworthy because it [employs] only the most universal rules of nature - the conservation of energy and momentum, the laws of chance and averages, the second law of thermodynamics, the fundamental properties of the atom, and so on."*
>
> -A.S. Eddington, 1926

Throughout much of the Western Hemisphere, the twentieth century was seen as the dawn of an era of great hope and promise. The hundreds of discoveries and inventions made during the preceding century - the fruits of science and technology - seemed to open up a vast treasure of possibilities in the latter part of the nineteenth century and the first few years of the 1900's. Edison lit up the world. The Impressionists painters freed by the invention of photography to explore and investigate new artistic techniques as they perceived rather than portrayed nature. Expanding horizons for individuals came into view at every turn.

> *radiation - n. 1. The act or process of radiating. 2. Physics. a. The emission and movement of waves, atomic particles, etc. through space or other media. b. The waves or particles that are emitted.*
>
> *radioactivity - n. 1. The spontaneous emission of radiation, either directly from unstable*
> *atomic nuclei or as a consequence of a nuclear reaction.*
>
> -The American Heritage Dictionary

In science, at the turn of the century, a veritable burst of discoveries ushered in the modern scientific era. Between 1859 and 1895, Darwin's Origin of Species saw publication, Dmitry Mendeleyev organized the elements into a periodic table that showed their relationships and hinted at the existence of an atomic structure and Joseph Lister

performed the first antiseptic surgery. From 1895 to 1912, a series of extraordinary scientific finds and theoretical breakthroughs would suddenly turn the world of physics topsy-turvy and thrust a new, modern scientific era upon the world. At the same time, these discoveries would place more power, both constructive and lethal, than ever before in the hands of human beings.

This task focuses on the beginning of the twentieth century (1885-1925) and on understanding the concepts of radiation and radioactivity. Beginning in the late 1800's, this period marks a time when most people believed that magic of modern life would continue forever. The discovery of radiation started a series of experiments around the world that would eventually lead to the basis for nuclear weapons. As scientists began to unravel the mysteries of the atom, they began to see the potential of their knowledge. But the good time of the early years, promising peace, prosperity, and pleasant living were fraught with problems caused by industrialization and urbanization.

Your task is to compare and contrast the endeavors of science and technology during the late 19th century to the early years of the 20th century.

You must examine events that established the corner stones of nuclear science and nuclear technology. Scrutinize these events in the context of the time periods. Research and gather data, within the context of the four domains (science, economic, social/cultural, and political/geo-political), that help you build an understanding of the "Era of Hope and Promise" in science and technology.

This task focuses on the Era of Hope and Promise in Science, 1885 to 1925. This period marks the discovery of radiation and the beginning of our understanding of nuclear science. Scientific knowledge and technological advances virtually created the positive, wild spirit of the industrial era. Using this as a reference point, address the following in relation to the time period:

1. Compare how science and technology have evolved in the period between 1885 and 1925 with that of previous time periods? How does it differ from the evolution of science and technology during previous time periods?
2. Describe the relationship between scientific development and technological development (cite examples) during this time period.
3. Politically and economically, the western world was progressively moving toward equality between men and women. How did the political and social environments of the day (cite examples) impact the pursuit of science?

4. How did the nationalism movement interpret and use the advances made by science and technology? Discuss the differing views toward the growth of science and technology in the new nationalistic visions.

5. Outline how the field of physics moved into a period of great vitality, excitement and confusion during the early years of the twentieth century, the beginning of modern physics. Begin with Roentgen's discovery of the X-ray. Explain why many people became concerned about the end of their personal privacy with the discovery and use of X-rays.

6. Politically and economically, the western world was entering a time of turmoil in the late nineteenth century and early twentieth century. How did the political and social environments of the day (cite examples) impact the pursuit of science?

Suggested Classroom Activities for Task #3

The following activities and questions are "hooks" for the work which is to come. While they are intended to generate discussion and promote understanding of and interest in the task, they are not directed specifically at any task question.

This task focuses on the time period called the "Era of Hope and Promise", from 1865 AD to 1925 AD. Using this as reference points, address the following in relation to the time period:

1. Have students identify technological advances based on the science discoveries of the late 19th and early 20th century. Develop a chart showing the new technology and the science behind it.
2. Identify nationalistic movements in Europe and the United States that would impact the scientific endeavor. Describe the different impacts.
3. Have students research how E. Goldstein discovered the positively charged sub-atomic particle and John Thomson discovered the electron. (Excuse me... how can you discover a particle so small that nobody has ever seen one?)
4. Develop a historical timeline for the discovery of the atom.
5. Have students build models of various atoms and describe how they may combine to build molecules.
6. What is radioactivity? How does it differ from radiation? How do radioactive properties of an atom compare with the atoms chemical properties?
7. Identify and describe the different kinds of radiation. List some health effects of these common radiations. What is the difference between ionizing and non-ionizing radiation. List uses for both ionizing and non-ionizing radiation.
8. Research and develop a short play on the discovery of radon and eventual health hazards that were encountered.
9. Have students research and discuss radioactive decay. How does this relate to the organization of the periodic table?
10. Complete the personal Radiation Survey [attached]. Design and conduct a radiation interview to discover what others believe.
11. Complete the table for the half-lives of significant radioisotopes listed [attached].

Task #4 – Splitting the Atom

"When I really understand something, it is as if I had discovered it myself."
-Richard Feynman

Fueled with the exciting discoveries of radioactivity, quantum theory and relativity, the first 25 or 30 years of the twentieth century witnessed an enormous fertility of ideas and discoveries unparalleled in the history of physics. A dynamic cluster of men and women - ambitious, brilliant, keenly prepared and talented - gathered in the universities of Europe, Britain and, to a lesser degree, Canada and the United States to ride the crest of a great wave of exploration into the inner regions of the atom.

This task area focuses on the events leading up to the development of the atomic bomb (1900-1939). Beginning in 1913, Niels Bohr modified the concept of electron orbits in the atom which led to his acclaim as the Father of Atomic Theory. Of course, Bohr's model of the atom is by no means the last word. Our ideas about the atom have changed a great deal since his announcement in 1913. The discoveries following Bohr would eventually lead to the splitting of the atom. As scientists continued their work splitting lighter elements, no one at the time thought that is was possible to split a uranium atom.

Your task is to discover and understand the implications of the scientific endeavors during the early years of the 20th century and the drivers that would lead to the Second World War.

You must examine events that further established the corner stones of nuclear science and nuclear technology. Scrutinize these events in the context of the time period. Research and gather data, within the context of the four domains (science, economic, social/cultural, and political/geo-political), that help you build an understanding of the events leading to "Splitting the Atom."

This task focuses on scientific discoveries during the early 20th century that led to scientists splitting the uranium atom. This period marks new discoveries and understanding of nuclear science. Scientific knowledge and technological advances virtually created a wild spirit leading to the nuclear age. Using this as a reference point, address the following in relation to the time period:

1. Beginning with Ernest Rutherford, outline the contributions of the following scientists in understanding the composition of the atom.

- Ernest Rutherford

- James Chadwick
- Ernest Lawrence
- John Douglas Cockroft & Ernest Thomas Sinton Walton

2. Trace the events that led to the beginning of the Manhattan Project starting with the realization in 1938 by Austrian physicists Lise Meitner and Otto Frisch that German chemists, Otto Hahn and Fritz Strassmann, had done the undoable. They had split the uranium atom. What political significance could such a scientific discovery have that would push the United States to the development of the atomic bomb?

3. Describe the political, social and economic environments that existed during the time period after World War I. Consider the scientific discoveries being made and how different political entities might have viewed them.

Suggested Classroom Activities for Task #4

The following activities and questions are "hooks" for the work which is to come. While they are intended to generate discussion and promote understanding of and interest in the task, they are not directed specifically at any task question.

This task focuses on the time period from 1900 to 1939. Using this as reference points, address the following in relation to the time period:

1. Have students identify technological advances based on the science discoveries of the early 20th century. Develop a chart showing the new technology and the science behind it.
2. Identify nationalistic movements in Europe and the United States that would impact the scientific endeavor. Describe the different impacts.
3. Have students research the German and Japanese scientific efforts of this time period.
4. Develop a historical timeline for the splitting of the atom.
5. Have students build models of the various atoms in the Uranium-238 decay chain and describe how the radioactively decay scheme.
6. Have students research and discuss the implications of the following scientific discoveries:

- Mendeleev's "Correlation Between Properties of Elements and Their Atomic Weights"
- Rutherford and Soddy's "Theory of Radioactive Disintegration"
- Thomson's "Plum Pudding Model"
- Planck's "Quantum Theory of Heat"
- Schrödinger's "Wave Mechanics"
- Aston's "Mass Spectorgraph"
- Joliot and Curie's "artificial radioactivity"

Task #5 – The Manhattan Project

"Now I am become death, a destroyer of worlds."
-J. Robert Oppenheimer, 1945
(quoting the Bhagavad Gita)

With the news that German scientists had achieved nuclear fission, consternation mounted in the United States about the possibility that Adolf Hitler might succeed in developing an atomic bomb. For such a weapon to fall into the hands of such an unprincipled leader in the midst of a war was unthinkable. In 1939 Leo Szilard persuaded Albert Einstein to convince U.S. president Franklin D. Roosevelt that the United States urgently needed to begin a crash program to develop a fission weapon. Einstein, a known pacifist, reluctantly backed such a project because Hitler and the Nazis had become the single most heinous force ever to gain power in the world. Thus the Manhattan Project was born.

This task area focuses on the events during the development of the atomic bomb and the time immediately following (1939 -1950). Beginning in 1939, the knowledge that uranium could be split and release tremendous amounts of energy, for an atom, set in motion a huge endeavor to discover ways to produce huge amounts of energy from the atom. This would necessitate a chain reaction if a bomb was to be developed. Following the war, the thought that such a weapon could be developed by other nations gave rise to the policy of deterrence thus leading to the Cold War.

Your task is to discover and understand the implications of the scientific and technological breakthroughs made during the years of the Manhattan Project and the drivers that led scientists and government leaders to develop the atomic bomb during the Second World War.

You must examine events that took place throughout the world as scientists rushed to further their understanding of nuclear science and nuclear technology. Scrutinize these events in the context of the time period. Research and gather data, within the context of the four domains (science, economic, social/cultural, and political/geo-political), that help you build an understanding of the events leading to the "development of the Atomic Bomb."

This task focuses on scientific discoveries during the mid-20th century that led to scientists developing and testing the atomic bomb. This period marks new discoveries and understanding of nuclear science. Scientific knowledge and technological advances

virtually created a world split between euphoria and fear giving rise to the thought that such a weapon could be developed by other nations thus the development of the policy of deterrence which lead to the Cold War. Using this as a reference point, address the following in relation to the time period:

1. Describe the political environment which created Second World War drove world renowned scientists toward the development of an atomic bomb.
2. What were the scientific contributions from the following? What were the political drivers behind each?

1. Enrico Fermi
2. J. Robert Oppenheimer
3. Edward Teller
4. George Eltenton
5. Klaus Fuchs
6. Werner Heisenberg
7. Robert Krohn
8. Edward McMillan
9. Frank Oppenheimer
10. Isidor I. Rabi
11. Robert Serber
12. Stanislaw Ulam
13. Robert Wilson

3. Describe the relationship of the different fields (mathematics, physics, chemistry, engineering) needed for the development of the atomic bomb. Why do you think biology was left off this list?
4. When the first atomic bomb was detonated over the desert of south central New Mexico, many of the scientists were ecstatic. The success represented , as one scientist said, "the best years of their lives" and J. Robert Oppenheimer was quoted, "Now I am become death, a destroyer of worlds.". Explain what these two quotes meant.
5. On July 26, 1945, U.S. president Harry S. Truman released a document known as the Potsdam Declaration. Its transmission was received by Japan on July 27. What was the significance of this declaration and the eventual detonation of the two atomic bombs on Japan?
6. When asked toward the end of his life what he thought of recent efforts toward nuclear arms control (mid 1960s), J. Robert Oppenheimer said, "It is twenty years too late. It should have been done the day after Trinity". Why did he, the father of the atomic bomb, feel this way? Explain why early talks would have/not have prevented the Cold War and eventual arms race?

7. If the United States and its allies had not developed the atomic bomb, what do think the eventuality of its development would have been? What do you think was the greatest legacy of the "bomb" in the years immediately following the end of World War II?

Suggested Classroom Activities for Task #5

The following activities and questions are "hooks" for the work which is to come. While they are intended to generate discussion and promote understanding of and interest in the task, they are not directed specifically at any task question.

This task focuses on the time period from 1939 to 1950. Using this as reference points, address the following in relation to the time period:

1. Have students compare and contrast the economic conditions leading up to World War I and World War II.
2. Assign the roles of Stalin, Churchill, and Truman to three students. Have the class research and prepare a text of the discussion between the three men at Potsdam. Discuss why the agreements made, at Potsdam were doomed to fail.
3. Hold a mock presidential cabinet meeting where President Truman discusses whether to share the secrets of the bomb with U.S. allies.
4. Research scientific activities that took place in Los Alamos during the Manhattan Project. Discuss the feelings that different scientists had during this time and immediately following the detonation of the test bomb.
5. Develop a media release to the public informing them of the successful test detonation of the first atomic bomb. Develop this release from two different perspectives, the media of the time and the media of today.
6. Develop and discuss possible scenarios that might have occurred if the U.S. had released atomic secrets at the end of the Second World War.

Task #6 – Beginning to End of the Nuclear Cold War

> *"If we fight a war and win it with H-bombs, what history will remember is not the ideals we were fighting for but the methods we used to accomplish them. These methods will be compared to the warfare of Genghis Khan who ruthlessly killed every last inhabitant of Persia."*
>
> -Hans A. Bethe.

The year 1945, a bitter and jubilant time marked the end of a terrible war - a world war that saw the annihilation of millions of Jewish people, the destruction of much of Europe, the unhinging of large parts of Asia and the Pacific, the decimation of two cities of Japan and the death of millions of other solders and civilians. At last, with great relief, the world could get back to the business of living. And scientists could get back to doing science.

The end of the Second World War brought peace and prosperity to the United States, but the political ambiance was not as peaceful. The world psyche after World War II was deeply shaken and the world could not escape the new anxieties created by the existence of the atomic bomb. Aggressive foreign policies led to an arms race and a new kind of conflict, the Cold War, began almost immediately. Using these as reference points, address the following:

> *"You say you want a revolution. Well, you know, We all want to change the world."*
>
> -John Lennon

By 1945, exploration of the new world within the atom had only just begun. Today some 200 subatomic particles are known, and more are believed to exist. The story of their discovery has been an intricate and intriguing whodunit that has absorbed some of the best minds of the century.

Today, there are as many scientists currently at work in the world as have existed in the entire history of science. Hundreds of specialties from computer science to microbiology and from astrophysics to particle physics attract young people who have a thirst for knowledge. Science provides us all, whether we are professional scientists or not, with a special window on the world that enables us to see in ways we might not otherwise see and understand in ways we would not otherwise understand. It is a special, and uniquely human, way of thinking. The end of the Cold War, the tearing down of the Berlin Wall and the development of computer aided global communications are some of the events

that are shaping the new history of today. The world around us is constantly changing, and with increases in technology, these changes seem to be occurring at a geometric pace. The ongoing revolution in science and technology is beset with political, social, economic and historical ramifications.

This task area focuses on the latter half of the twentieth century, from 1945 to the present, on the events culminating with the end of the Cold War and the beginning of International collaboration. In the latter half of the century, science is viewed as both hero and villain. Blamed for the loss of the simple, natural life, science has given us the conveniences of the modern, complex life; from electricity to compact discs, automobiles and airplanes to space exploration, from satellite communication to fax machines, computers, and e-mail. And the cycle continues: discovery-spawning technology, which in turn leads to new discoveries leap froging into the future. It is at this point that we find ourselves today.

Your task is to discover and understand the implications of the scientific and technological breakthroughs made after the Manhattan Project and the drivers that led scientists and government leaders to develop and test more powerful bombs.

You must examine events that took place throughout the world as scientists rushed to further their understanding of nuclear science and nuclear technology. Scrutinize these events in the context of the time period. Research and gather data, within the context of the four domains (science, economic, social/cultural, and political/geo-political), that help you build an understanding of the events leading to "nuclear arms escalation." and the strained relations between global powers.

This task focuses on scientific discoveries during the latter part of the 20th century that led to scientists developing and testing the hydrogen bomb. This period marks new discoveries and understanding of nuclear science. Scientific knowledge and technological advances virtually created a world split gripped with fear giving rise to the nuclear arms race, the policy of deterrence, and competition in space exploration. Using this as a reference point, address the following in relation to the time period:

1. Compare and contrast the Cold War from the perspectives of the "West" and the "East". Explain why the Cold War was a scientific war as well as a political war.
2.Information about radiation, nuclear materials, and nuclear testing results were considered top secret and vital to national security during the Cold War. What were the effects of this secrecy on the public? How did the public learn about nuclear things

during the 1950's? How did you learn about nuclear things and what are your feelings toward them?

3.Fear of nuclear weapons is justifiable. What are your thoughts on other uses of nuclear material? What was the probability for completely eliminating nuclear materials from our world during the Cold War? What were the views on managing nuclear materials for the good of human kind during this period of time?

4.In the early 1970s, the U.S. Department of Defense began a network of military computers dubbed ARPAnet (Advanced Research Projects Agency network). This effort turned out to be the forerunner of today's Internet. Describe the use of the Internet today as an information source. How has the Internet affected society? How has it affected education and the art of studying?

5.The end of the Cold War sees the world entering a new phase. What are the impacts, positive and negative, that exist as a result of the Legacy of the Cold War Period? Include an assessment of risk, public attitudes and concerns.

> *"As similar as human beings are in many ways to other species, we are unique among the earth's life forms in our ability to use language and thoughts.*
>
> *We are also unique in our profound curiosity about ourselves."*
>
> -From Science for All Americans

Suggested Classroom Activities for Task #6

The following activities and questions are "hooks" for the work which is to come. While they are intended to generate discussion and promote understanding of and interest in the task, they are not directed specifically at any task question.

This task focuses on the time period from 1945 to the present. Using this as reference points, address the following in relation to the time period:

1. Research the period known as "The Cold War". Develop a comparison chart with heading for scientific endeavors and for political endeavors.
2. During the Cold War period, scientists from different fields (mathematics, physics, chemistry, engineering, biology, etc.) were recruited for the newly emerging national laboratories. Develop a chart showing the emphasis of their research and any spin-offs of their research that benefited society.
3. Discuss the political ramifications of the launch of "Sputnik"/ Discuss how it affected the direction of scientific research and the effect it had on education in the United States?
4. John Fitzgerald Kennedy once said, "We seek not the world-wide victory of one nation or system but a world-wide victory of man. The modern globe is too small, its weapons too destructive, and its disorders too contagious to permit any other kind of victory." Given the political and economic conditions during the years that followed the Second World War, debate the likelihood that his vision would come to fruition and the likelihood that the world can achieve this goal in today's political and economic environments?
5. Research all uses of nuclear material? Discuss the probability for completely eliminating nuclear materials from our world.
6. Discuss how the Freedom of Information Act, which made available information that for long had been classified and kept away from public dissemination, has this impacted the scientific endeavor? Discuss the effect it has had on the political and social worlds?
7. Trace the history of the Internet, and discuss the use of the Internet today.
8. Compare the directions of scientific research during the "Cold War" period and the present.
9. Discuss how other countries view issues focusing on monitoring of materials, developing organizations and signing treaties to deal effectively with "things nuclear" compared with the United States position.
10. Develop a survey to administer to community members of all ages in order to gage the awareness of the public on the issues and areas you have studied this semester. Compile and interpret the survey results Discuss the implications of the results.